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ABSTRACT

This study tested two hypotheses: (1) that significant differences exist, across academic levels, in science teachers' conceptions about the nature of learning; and (2) that corresponding differences exist in how science teachers formulate, carry out, and monitor instruction/classroom activities, and in the kinds of study activities they encourage their students to perform. Eight middle school teachers, 10 high school teachers, and 9 college professors participated in the study. A teacher survey questionnaire was composed of the following dimensions: (1) indicators of a successful science student, (2) factors that influence student learning, (3) kinds of student study activities encouraged by teachers, and (4) teaching activities. Among the conclusions were: the major differences on these scales were between college and high school teachers, and college teachers tend to emphasize more cognitive processing strategies for learning, i.e. emphasizing student's attempts to learn, remember and understand academic information. In contrast, high school teachers tend to emphasize more effort management, self-regulatory skills, and environmental monitoring activities (e.g. goal setting, keeping to a schedule, feedback). (PR)

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DISCONTINUITIES IN SCIENCE TEACHERS' INSTRUCTIONAL BELIEFS AND PRACTICES ACROSS GRADE LEVELS

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Discontinuities in science teachers' instructional beliefs and practices across grade levels

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This paper describes an ongoing investigation with two primary components. First, we have been surveying middle school, high school, and college science teachers' conceptions of what factors best predict or strongly influence student learning. Second, we have been examining the classroom practices employed by these teachers to effect student learning. Our goal has been to determine whether differences exist, between academic levels, among science teachers' instructional beliefs and practices that might influence students' conceptual understandings of science.

Our investigation has been directed by several outcomes reported in recent instructional research literature. First, effective teaching promotes students' conceptual understanding of, rather than merely knowledge about, concepts and principles (Anderson & Smith, 1987), and successful teachers design instructional activities to facilitate this higher level outcome. Second, such activities are informed by teachers' beliefs and knowledge about the subject matter as well as their beliefs and knowledge about how to promote learning of that subject matter (Stein, Baxter, & Leinhardt, 1990). Third, teachers' beliefs both about the subject matter and about student learning can differ substantially across grade levels (Anderson & Smith, 1987), yielding considerable variability in the kinds of instructional activities students experience and the learning goals students are required to achieve (Thomas, Bol & Warkentin, 1991). Finally, as a result of different instructional practices from one grade level to the next, students' understandings of content, their strategies for acquiring content-specific concepts, and their interests in similar learning experiences may be impeded (Hurd, 1982; National Commission on Excellence in Education, 1983; Thomas & Rohwer, 1987).

Based on the literature discussed above, the present study of middle school, high school, and college science teachers' instructional beliefs and practices tested two hypotheses: 1) that significant differences exist, across academic levels, in science teachers' conceptions about the nature of learning; and, 2) that corresponding differences exist in how science teachers formulate, carry out, and monitor instruction/classroom activities, and in the kinds of study activities they encourage their students to perform. We speculate that, to the extent these teacher beliefs and practices are inconsistent across grade levels, students' science learning may be impeded.

METHOD

Participants

Eight middle school teachers, ten high school teachers and nine college professors participated in the study. The middle and high schools are feeder schools to each other, and the college is a regional one, drawing mostly from the local population of high school graduates. All middle school participants were 7th-grade life science teachers, and all high school participants regularly teach one or more life science course (biology, anatomy & physiology, etc.), averaging 8.3 years and 9.7 years of teaching experience, respectively. The college professors (all Ph.D) teach an introductory biology course (general education life science requirement), and report an average of 12 years of teaching experience.

Teacher Survey Questionnaire

The Teacher Survey Questionnaire is a self-report instrument that is based on the following four dimensions or scales:

Indicators of a successful science student. Participants rated 27 statements of behaviors and dispositions that may indicate a successful science student (e.g., volunteers ideas and opinions, enjoys learning the subject, solves problems creatively), on a 4-point Likert scale ranging from 1 (Not Important) to 4 (Very Important).

Factors that influence student learning. Participants' perceptions of what factors most influence students' classroom learning were assessed from their ratings of 19 statements (e.g., positive teacher attitude, student's current knowledge about science, emotionally supportive home environment) on a 4-point Likert scale ranging from 1 (Not Important) to 4 (Very Important).

Kinds of student study activities encouraged by teachers. Participants rated the extent to which they encouraged their students to engage in 21 study activities using a 4-point Likert scale ranging from 1 (Not at all) to 4 (To a great extent). Two classes of activities were included: a) cognitive processing activities (14 statements, e.g., concentrate on finding important parts of the material); and, b) self-management or self-regulatory activities (7 statements, e.g., study in a quite place).

Teaching activities. Participants rated how frequently they used 17 teaching activities (e.g., lecture, whole group discussion, independent science projects, etc.) on a 5-point Likert scale ranging from 1 (Very Rarely Used) to 5 (Used Every Day). These activities were taken from the National Education Longitudinal Study (NELS, 1988).

Procedure

Teachers and professors who taught the appropriate life science course (at each level) were notified in person or by telephone and asked to participate. Questionnaires were delivered in person to participants' schools, along with addressed, stamped envelopes for their return. Participants were requested to complete the questionnaire at their convenience (involving approximately 45 minutes), and to return it within a week. All participants were assured that their responses would be kept confidential and anonymous. Of the 10 instructors at each academic level originally solicited, only 2 middle school teachers and 1 college professor did not return their completed questionnaires.

RESULTS AND DISCUSSION

First, descriptive data is given on each of the four scales. Then, each scale is analyzed separately for construct validity and for specific differences between the three academic levels.

Descriptive information

Descriptive information for each of the scales is given in Table 1.
The reliabilities range from adequate to good.

What are the most important indicators of a successful science student?

A) Construct validity

The frequency of the teachers' responses to the items on the "Indicators of a successful science student" scale are shown in Table 2. The items are rank ordered according to the proportion of teachers endorsing the item as "very important" on the Likert scale.

The responses of the teachers were scaled using the statistical modeling procedure Partial Credit, one member of the family of Item Response Theory (IRT) models. This procedure, in addition to providing psychometric item quality information, provides an item value and associated error term for each item. The IRT procedure places the items on a logit scale (interval scale). Lower scale values indicate more agreement to the item, whereas higher scale values indicate less agreement. Notice that the IRT item values parallel the actual proportion of teacher agreement.

The unique ordering of the items provides information about the nature of the underlying construct. Examination of this pattern suggests one interpretation of the construct based on the following four observations. First, a cluster of items that received strong agreement are items #14, "Understands concepts," #16, "Applies concepts to real life situations," and #18, "Discovers relationships." These items describe a successful student as one who engages in cognitive processing activities that enhance meaningful, deep-level learning and understanding (rather than rote memorization or surface familiarity).

A second cluster of items receiving strong agreement (but not as strong as the first cluster) tend to describe a successful student as one who displays productive effort management activities and good study habits. These items, #15 "Knows where to find answers," #3 "Attends class regularly," #7 "Attends to lecture demonstrations," #4 "Follows instructions," and #10 "Comes to class prepared," emphasize self-regulation of time, concentration, and persistence. These activities have been shown to significantly increase student achievement by setting the occasion for productive, efficient learning.

A third set of items, #21 "Reviews notes regularly," #9 "Completes class assignments on time," #19 "Sets realistic goals," #6 "Participates in class discussion," #5 "Takes organized notes," #12 "Stays on task," are activities similar to the previous items in that they emphasize effort management behavior, however, they have been judged to be weak indicators of a successful student. Perhaps these activities are performed well by most students and therefore do not differentiate the successful from the unsuccessful student.

Table 2 shows how these items are categorized into two dimensions: Learning for understanding -cognitive skill to learn, and Effort management -will to learn. A successful science student then, is one who engages in deep-level understanding, and who displays distinctive efforts to manage their study behavior.

Finally, and quite surprisingly, item #23, "Shows a high level of achievement," received very few teacher endorsements. Apparently, teachers believe that doing well on academic tests is not a very important indicator of a successful student. Perhaps this reflects the belief that doing well on achievement exams does not necessarily mean that such students can *do* science on their own independently outside the classroom, or that they possess deep understanding of science concepts.

B) Differences between academic levels

College versus High school

One way to display differences between academic levels is to compare the response pattern for each group of teachers. This analysis requires that the set of items be scaled separately for each academic level using the IRT method. The item values for each group can then be plotted on a graph. One such comparison is presented in Figure 1. The horizontal axis represents the scale defined by the college teachers with items agreed to more located on the left side of the scale. The vertical axis represents the scale defined by the high school teachers with items agreed to more located on the bottom of the scale. A dot is placed at the intersection of the item value derived from the college professors' ratings and the item value derived from the high school teachers' ratings. Those items that fall close to the identity line have received the same rating, thus there is congruence between the way the two groups of teachers have responded to the items. For

example, items #14, "Understands concepts," #18, "Discovers relationships," and #6, "Participates in class discussion," all received almost identical ratings from both groups of teachers. Further, item #14 was rated quite favorably by both college and high school teachers (the dot is close to the bottom left), whereas item #6 was rated relatively less favorably by both college and high school teachers (the dot is closer to the top right).

The 95% confidence bounds have been drawn in Figure 1. As can be seen, items that have been rated very differently fall outside of these lines. These items are shown in Table 3. Items rated more importantly by high school teachers are listed in the top part of the table. The three items #4, #3, #5 all refer to students' ability to follow instructions, to be diligent and attentive (all effort management kinds of activities). These results suggest that high school teachers tend to view effort management skills as more important indicators of success. In addition, there is more importance placed on the students' feelings of self by the high school teachers. In contrast, items endorsed more frequently by college professors, presented in the lower part of Table 3 (Items #11, #26, #25), tend to emphasize cognitive learning skills and, in particular, problem solving activities.

These results reflect two areas of possible discontinuity between college and high school teachers' conception of a successful student: (a) high school teachers place more importance on student behavior that demonstrates effort management and good feelings about self, whereas, (b) college teachers, place more importance on students' problem-solving ability and application of science information.

High school and Middle school

Figure 2 displays the response patterns for high school and middle school teachers. Very minor differences are observed. In general, there is much more congruence in the way the middle school and high school teachers judged the items than the college-versus-high school teacher ratings.

What are the most important factors that influence student learning?

A) Construct validity

Teachers' responses to the items on this scale are shown in Table 4. The items are ordered according to how frequently they were rated as "Very important" factors affecting student learning. Do the teachers' responses form a coherent pattern defining the underlying variable?

Items agreed to most frequently are #7 "Positive teaching attitude," & #5, "Motivating students to learn." These items emphasize teachers' efforts to motivate and increase student interest in science. Similarly, items #12, "Hands-on science experiences," #8 "Variety of instructional methods," emphasize teachers' actions to involve students directly with science material in creative ways. In general, the common element appears to be teachers' attempts to make science information relevant, interesting and creative to students.

Items that define the middle of the scale, #3 "Rules, regulations, procedures," #14, "Class size," #2 "Review material often," and #17, "Student completes assignments," and #4 "Feedback on homework assignments," involve classroom environmental factors (not directly related to student interest or motivation) that emphasize procedures, constraints, feedback and monitoring of student work and progress.

Items receiving the fewest agreements, and thus deemed least important, are items #13, "Informational handouts," #1, "Provide goals and objectives," #10, "Variety of assessment measures," and #9 "Frequent testing." These items tend to be less intrinsically interesting to students and perhaps more anxiety arousing.

Finally, note the very surprizing result regarding #15, "Student's current knowledge about science." Contrary to current cognitive views of learning, this factor is viewed by teachers as exerting a very weak influence on student learning.

In sum, teachers' responses indicate that the most important factors influencing student learning are, (a) teacher initiated activities designed to enhance student interest and motivation in the subject matter and, (b) to a lesser extent, environmental feedback and monitoring procedures. Factors deemed less important are more distantly related to student interest (e.g., assessment, testing, goals and objectives) and are possibly more stress inducing.

B) Differences between academic levels

College versus High school

The same procedure, as described earlier, was used to compare the groups. Item values were calculated separately for each group (using the Partial Credit IRT method) and then plotted on a graph. Figure 3 shows this comparison for the college and high school groups. Each point on the graph indicates the location on the scale where college and high school teacher ratings intersect. Item points that fall near the identity line have received similar ratings. The figure also displays the 95% confidence bounds.

As can be seen, four items fall outside of the confidence bounds indicating differences between academic levels. These items are presented in the top of Table 5. In particular, items #3, "Rules and regulations," #4 "Feedback on homework," #17, "Student completes assignments on time," and #19, "Supportive home," were rated significantly more important by high school teachers than college professors. Thus, high school teachers, compared to their college counterparts, perceive environmental constraints and assignment-monitoring factors to be much more influential in affecting student learning.

High school versus Middle school

Figure 4 compares the item scale values for the high school and middle school teachers. Two items #19 "Supportive home, and #17 "Student completes assignments on time," fall outside of the 95% confidence bounds. These items are presented in the bottom of Table 5. As shown, high school teachers rate these factors significantly more important than middle school teachers. The difference again points out the relative importance placed on environmental and monitoring factors by the high school teachers.

In summary, the results point out a possible area of incongruity between academic levels in beliefs about what most influences student learning. High school teachers, more than college and somewhat more than middle school teachers, perceive factors that provide students with a structure for learning, or a structure for monitoring students' progress to be more important influences on learning.

<u>Study activities teachers encourage in their students</u>

A) Construct validity

Table 6 presents the proportion of teachers who rated each item as a "very important" study activity they encourage in their students. The items are ranked ordered in proportion of agreement and the corresponding IRT analysis is given. Is a coherent variable defined by this pattern of responses? A possible interpretation of the meaning of this scale can be made by the following observations.

Items receiving relatively high endorsement can be categorized into two related clusters. In the first cluster are items #2, #7, #3, #4, #5, #10, #11. These items are all cognitive study activities that foster deep-level, semantic or meaningful learning. These items are marked in Table 6 with a check.

The second cluster of items receiving strong endorsement (but not as strong as the first), items #21, #22, #18, #20, #23, #15, focus on self-management or effort management behaviors. These activities ensure that students are prepared and organized by having prepared notes, being persistent, scheduling regular time for studying, possessing a good attitude. These items are also marked in Table 6 with an X.

Thus, the scale appears to be defined in terms of two dimensions. First, teachers are primarily interested in encouraging in their students study activities that will enhance meaningfully understanding of science material. These are cognitive strategies applied to learning information. Second, teachers encourage students to develop effort management activities.

B) Differences between academic levels

College versus High school

Following the same procedure as described above, an item analysis using Partial Credit (IRT) was performed for each group of teachers separately and the resulting item values were plotted on a graph. Figure 5 shows this comparison with the identity line and 95% confidence bounds drawn in for the college and high school teachers.

Two groups of items with the most discrepant ratings have been identified. The first group have been rated more important by the college teachers (items #10, #11, #3, #5). The second group of items were rated more important by high school teachers (#22, #4, #20). These items are presented in Table 7. As can be seen, the items rated more importantly by college teachers (the top part of the table) emphasize cognitive strategies for learning (e.g, "Summarize information in own words," and "Make graphs, charts and tables to help remember the information"). The items rated more importantly by high school teachers, in contrast, emphasize effort management behavior #22, #20, e.g., "Set learning goals," and "Keep schedule of test dates."

High school versus Middle school

The item comparisons for the high school and middle school teachers are presented in Figure 6. Differences between groups in the pattern of responses is much less than between high school and college. Item #2 "Find the important parts of the material" was rated significantly more important by middle teachers.

In general, all teachers seek to encourage their students to engage in study activities that foster deep-level meaningful learning of science information rather than rote memory activities. Thus, students are encouraged to find, relate and apply principles and concepts. In addition, all of the teachers agree rather strongly with the importance of effort-management and self-regulatory study behaviors (e.g., good study habits for persistence, goal setting, scheduling, etc.). However, college professors appear to place more value and importance on students' ability to use cognitive information processing study strategies (summarize, make graph, relate and apply). High school teachers, in contrast, value activities that structure students' efforts (scheduling, goal setting)

<u>What teaching or classroom activities do teachers use most often?</u>

Those teaching activities that were rated significantly different by the three groups of teachers are presented in Table 8. These results can be summarized as follows: As expected, the college professors, and to a lesser extent the high school teachers, reported a higher frequency for lecturing activities (2-3 times a week), in contrast to the middle school teachers (once a week). The high school and middle school teachers reported using more worksheet completion activities and individual seatwork assignments performed in class than the college professors, and the middle school teachers reported having students work in small groups more often than did the college professors.

In contrast to these between-level differences, all science instructors agreed on the values of two teaching practices (presented in Table 9): having students respond to oral questions about the subject matter was the single most used instructional technique, whereas the least used instructional activity was having students independently design and conduct their own science projects.

Conclusions

The major differences on these scales were noted between the college and high school teachers. It was found that college teachers tend to emphasize more cognitive processing strategies for learning, i.e., emphasizing student's attempts to learn, remember and understand academic information (e.g, summarizing, making graphs, and relating information together). In contrast, high school teachers tend to emphasize more effort management, self-regulatory skills, and environmental monitoring activities (e.g., goal setting, keeping to a schedule, feedback).

Taken together, these results indicate what may be significant discontinuities across grade levels in science teachers' beliefs about student learning and the kinds of teaching practices used to help students learn and study science. These discontinuities may account for some of the difficulty students experience while learning science, and some of the decline in interest among students to pursue science careers and advanced degrees. Moreover, even when common trends were found across the education levels in teacher belief-practice indices, some of these were contrary to current evidence regarding cognitive learning. On a positive note however, a number of the trends revealed that instructors did value and teach important foundational skills and attitudes. As students form their understanding of science concepts and develop learning strategies over the developmental years, it is important to provide them with a continuous and coherent foundation so that they can build optimal conceptual understandings of science.

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Table 1. Descriptive data on scales.

Scale name	Mean	Stand. Dev	Alpha Coef.	No. of Items	Likert categories
Indicators of a successful science student	87.34	9.92	.89	27	1-4*
Factors that influence student learning	61.00	6.03	.78	19	1-4*
Study Activities encouraged in students	74.07	6.31	.72	21	1-4**
Teaching or classroom activities	40.88	4.44	NA	17	1-5***

*Likert categories 1 = Not important to 4 = Very important
**Likert categories 1 = Not at all to 4 = To a great extent
***Likert categories: 1 = Very rarely to 5 = Everyday.
Number of teachers responding to each scale = 26.

Table 2. Indicators of a successful science student scale. The proportion of teachers' responses to the items and the Partial Credit analysis results.

		Item #	Item Name	% of teachers agree strongly	Partial Credit Analysis IRT Item value	error
√		14	Understands concepts	0.77	-0.55	0.50
	X	15	Knows where to find answers	0.65	0.09	0.45
√		16	Applies concept to real life situation	0.65	0.17	0.86
	X	3	Attends class regularly	0.62	0.28	0.44
√		18	Discovers relationships	0.62	0.31	0.85
	X	7	Attends to lecture demo	0.58	0.47	0.44
	X	17	Makes extra effort on difficult tasks	0.58	0.49	0.82
	X	4	Follows instructions	0.54	0.64	0.88
		27	Feels good about self	0.54	0.63	0.81
	X	10	Comes to class prepared	0.50	0.81	0.81
√		11	Enjoys learning science	0.50	0.81	0.83
		24	Keeps open mind	0.50	0.81	0.83
√		25	Solves problems logically	0.46	0.98	0.83
		8	Posses thought provoking questions	0.38	1.26	0.74
√		20	Shows curiosity	0.38	1.30	0.80
	X	21	Review notes regularly	0.38	1.25	0.75
√		26	Solves problems creatively	0.38	1.33	0.80
	X	2	Works cooperatively in groups	0.35	1.41	0.76
	X	9	Completes class assignments on time	0.35	1.45	0.79
	X	19	Sets realistic goals	0.35	1.52	0.82
	X	6	Participates in class discussion	0.31	1.55	0.79
	X	22	Gathers useful information	0.27	1.80	0.77
	X	12	Stays on task	0.27	1.95	0.86
	X	5	Takes organized notes	0.27	1.87	0.84
		1	Volunteers ideas and opinions	0.23	2.06	0.83
		23	Shows high level achievement	0.15	2.58	0.94
		13	Memorizes vocabulary	0.04	4.38	1.61

Key

√ Cognitive strategies for learning and understanding

X Effort management of diligence and persistence and organization

Table 3. Indicators of a successful science student scale. Comparison between college and high school teachers' ratings. Items rated more important by high school teachers than by college teachers top part of table. Items rated more important by college than by high school teachers bottom part of table.

	Item #	Item Name	College teachers % agree	College teachers item value	High school teachers % agree	High school teachers item value
	27	Feels good about self	0.11	2.31	0.90	-1.94
X	4	Follows instructions	0.22	1.58	0.80	-0.94
X	3	Attends class regularly	0.33	1.07	0.80	-0.94
X	5	Takes organized notes	0.11	2.40	0.60	0.36

Scale dimension
X - Effort activities

	Item #	Item Name	College teachers % agree	College teachers item value	High school teachers % agree	High school teachers item value
√	11	Enjoys learning science	0.78	-1.00	0.50	0.79
√	25	Solves problems logically	0.67	-0.40	0.40	1.34
√	26	Solves problems creatively	0.56	0.10	0.30	1.90

Scale dimension
√ - Understanding activities

Table 4. Factors That Influence Students' Learning scale. The proportion of teachers' responses to the items and the Partial Credit analysis results.

	Item #	Item Name	% of Teachers Agree Strongly	Partial Credit Analysis Item Value	Error
*	7	Positive teaching attitude	0.85	-1.15	0.56
*	5	Motivating students to learn	0.81	-0.87	0.52
	11	Expectation/standards for performance	0.54	0.49	0.83
*	12	Hands-on science experiences	0.54	0.49	0.83
*	8	Variety of instructional methods	0.54	0.50	0.83
	19	Supportive home	0.50	0.65	0.77
√	3	Rules, regulations, procedures	0.46	0.76	0.71
	6	Develop rapport	0.46	0.78	0.75
√	14	Class size	0.46	0.78	0.75
	18	Student's study strategies	0.46	0.82	0.83
√	2	Review material often	0.42	0.96	0.76
√	17	Student completes assignments on time	0.42	0.98	0.79
	16	Student's attitude toward science	0.38	1.18	0.44
√	4	Feedback on homework assignments	0.35	1.30	0.84
£	13	Handouts summarizing information	0.23	1.61	0.78
£	1	Provide goals & objectives	0.27	1.64	0.83
£	10	Variety of assessment measures	0.23	1.81	0.77
	15	Student's current knowledge about science	0.08	2.92	1.04
£	9	Frequent testing	0.04	3.55	1.32

Key: Dimension of scale

* Teacher provisions to increase student motivation and interest in subject

√ Environmental procedures, constraints, feedback and monitoring of student work

£ Less motivating to student and more anxiety producing

Table 5. Factors That Influence Students' Learning scale. Factors rated more important by high school teachers than by college teachers top part of table. Factors rated more important by high school teachers than middle school teachers bottom part of table.

	Item #	Item Name	College teachers % agree	College teachers item value	High school teachers % agree	High school teachers item value
√	3	Rules, regulations, procedures	0.00	NA	0.70	-0.29
√	4	Feedback on homework assignments	0.00	NA	0.70	-0.11
√	17	Student completes assignments on time	0.22	1.33	0.80	-0.84
√	19	Supportive home	0.22	1.08	0.90	-1.65

	Item #	Item Name	High school teachers % agree	High school teachers item value	Middle school teachers % agree	Middle school teachers item value
√	19	Supportive home	0.90	-1.65	0.29	1.09
√	17	Student completes assignments	0.80	-0.84	0.14	2.04

Key:

√ Environmental procedures, constraints, feedback and monitoring of student work

Table 6. Study activities teachers encourage in their students scale. The proportion of teachers' responses to the items and the Partial Credit analysis results.

		Item #	Item Name	% of Teachers Strongly Agree	Partial Credit analysis Item Value	Error
		17	Ask for help when needed	0.92	-1.82	0.75
	√	2	Find important parts of material	0.73	-0.19	0.97
	√	7	Focus on principles and concepts	0.65	0.09	0.91
	√	3	Relate science concepts together	0.54	0.54	0.84
	√	4	Relate scnce info to personal experience	0.50	0.70	0.41
	√	5	Apply science information to problems	0.50	0.69	0.82
		13	Construct study notes	0.50	0.70	0.74
X		21	Persist when studying is difficult	0.50	0.70	0.74
X		22	Set learning/achievement goals	0.50	0.71	0.72
	√	10	Summarize information in own words	0.46	0.85	0.77
X		18	Set aside a regular study time	0.46	0.82	0.71
X		20	Keep a schedule of test dates	0.46	0.84	0.74
		6	Focus on facts and details	0.38	1.13	0.75
	√	11	Make graphs, charts to remember inform	0.38	1.16	0.77
X		23	Evaluate efforts after studying	0.38	1.07	0.72
	√	14	Quiz oneself while studying	0.35	1.26	0.76
		16	Participate in small grp study sessions	0.35	1.21	0.73
		9	Use memory techniques	0.31	1.28	0.68
X		15	Study in quiet place	0.31	1.42	0.72
		12	Read course handouts	0.27	1.51	0.74
		19	Develop good plan for assignments	0.27	1.54	0.70
		1	Read, reread textbook	0.23	1.91	0.87
		8	Memorize information word-for-word	0.04	3.13	1.22

Key

√ Cognitive activities to enhance understanding or meaningful learning

X Effort management activities

Table 7. Study activities teachers encourage in their students. Comparisons between college and high school teachers. Items rated more important by college teachers than by high school teachers top part of table. Items rated more important by high school teachers than by college teachers bottom part of table.

	Item #	Item Name	College teachers % agree	College teachers item value	High school teachers % agree	High school teachers item value
√	10	Summarize information in own words	0.77	-0.48	0.20	1.85
√	11	Make graphs, charts to remember infor	0.77	-0.62	0.30	1.33
√	3	Relate science concepts together	0.66	-0.46	0.40	0.93
√	5	Apply science information to problems	0.66	-0.30	0.40	0.93

	Item #	Item Name	College teachers % agree	College teachers item value	High school teachers % agree	High school teachers item value
X	20	Keep a schedule of test dates	0.11	2.14	0.60	0.20
X	22	Set learning/achievement goals	0.11	2.14	0.70	-0.16
	4	Relate science infomation to personal experience	0.33	0.95	0.70	-0.35

Key

√ Cognitive activities to enhance understanding meaningful learning

X Effort management activities

Table 8. Mean ratings on three items that are significantly different (ANOVA p. < .05) on the "Teaching or classroom activities" scale. (Likert categories: 1 = Very rarely; 2 = 1-2 times a month; 3 = Once a week; 4 = 2-3 times per week; 5 = Everyday.)

Teaching activity	College	High school	Middle school
Lecture	4.44	4.11	3.28
Have students complete individual worksheets in class.	1.66	3.44	3.85
Have students work in small groups	2.22	2.90	3.28

Table 9. Mean ratings on two items that were most frequently used and least frequently used on the "Teaching or classroom activities" scale. (Likert categories: 1 = Very rarely; 2 = 1-2 times a month; 3 = Once a week; 4 = 2-3 times per week; 5 = Everyday.)

Teaching activity	College	High school	Middle school
Have students respond orally to questions	4.78	4.60	4.57
Have students independently design and conduct their own science projects	1.55	1.20	1.14

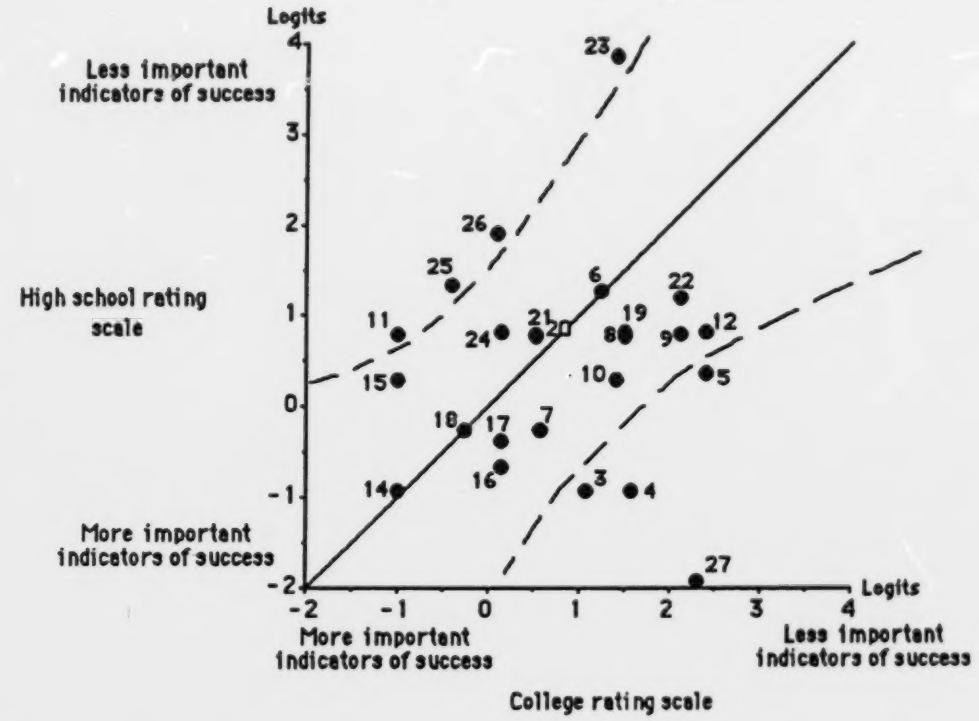
Logits
Less important indicators of success
High school rating scale
More important indicators of success
More important indicators of success
Less important indicators of success
College rating scale
Logits

Fig.1

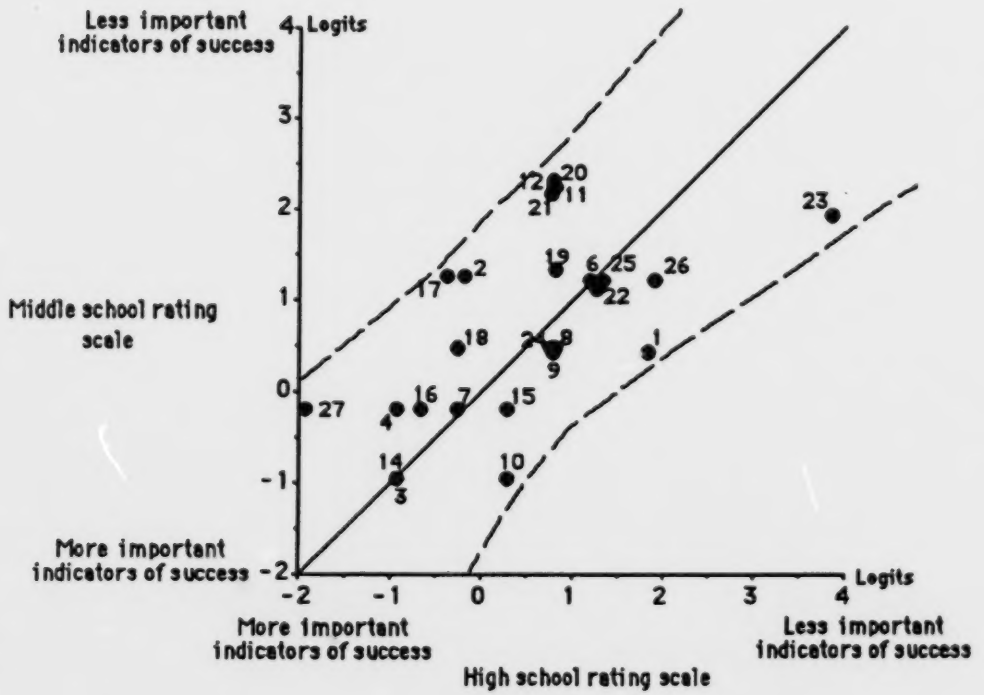
Less important indicators of success
Logits
Middle school rating scale
More important indicators of success
More important indicators of success
Less important indicators of success
High school rating scale
Logits

Fig. 2

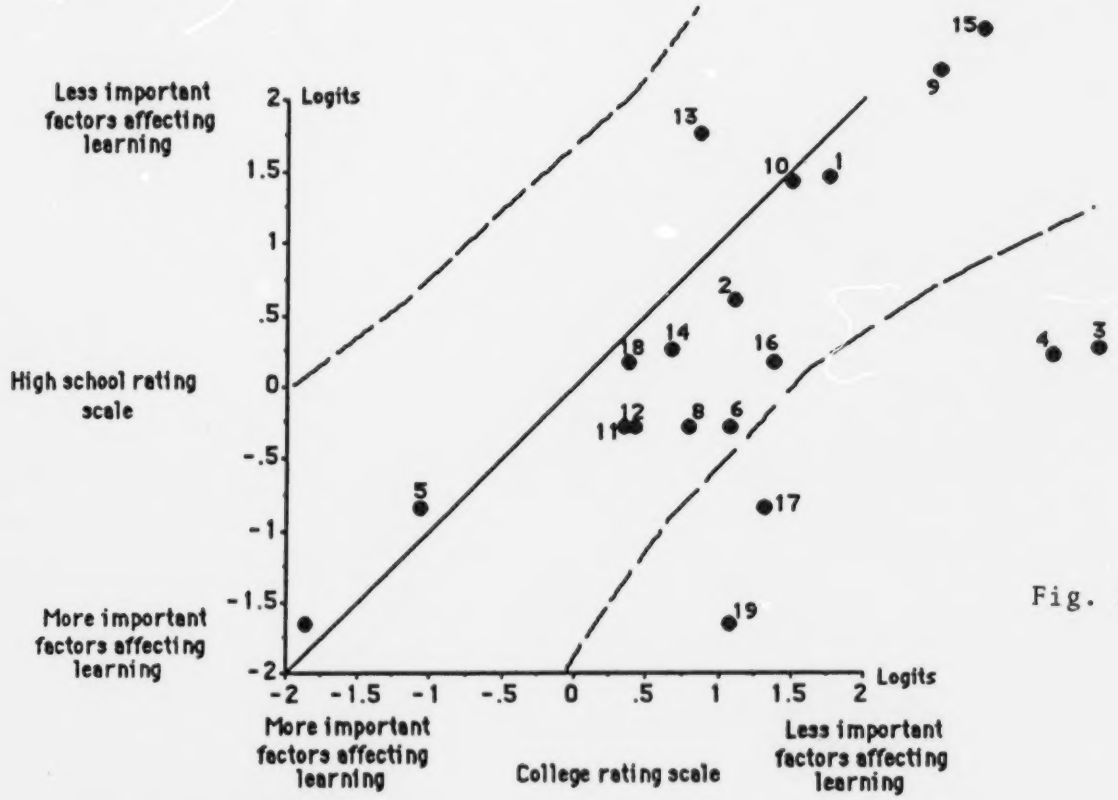
Less important factors affecting learning
Logits
High school rating scale
More important factors affecting learning
2
1.5
1
.5
0
-.5
-1
-1.5
-2
-2 -1.5 -1 -.5 0 .5 1 1.5 2
Logits
More important factors affecting learning
College rating scale
Less important factors affecting learning
15
9
13
10
1
2
14
18
16
4
3
12
11
8
6
5
17
19

Fig. 3

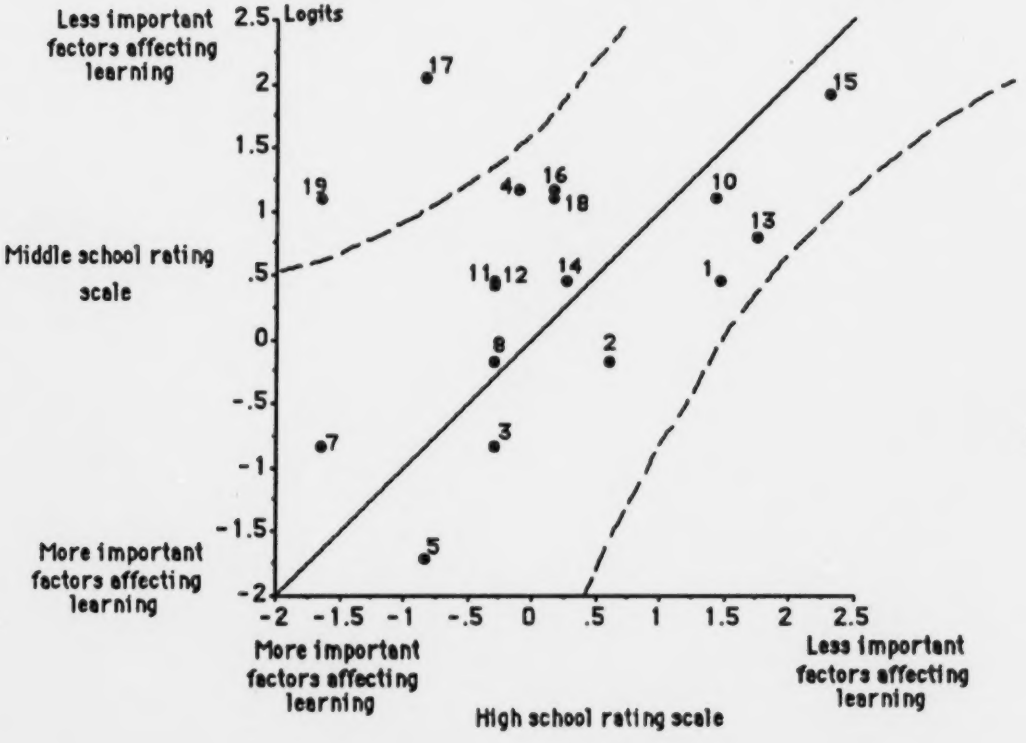
Less important factors affecting learning
Logits
Middle school rating scale
More important factors affecting learning
2.5
2
1.5
1
.5
0
-.5
-1
-1.5
-2
-2 -1.5 -1 -.5 0 .5 1 1.5 2 2.5
More important factors affecting learning
High school rating scale
Less important factors affecting learning
17
15
19
4
16
18
10
13
11
12
14
1
8
2
7
3
5

Fig. 4

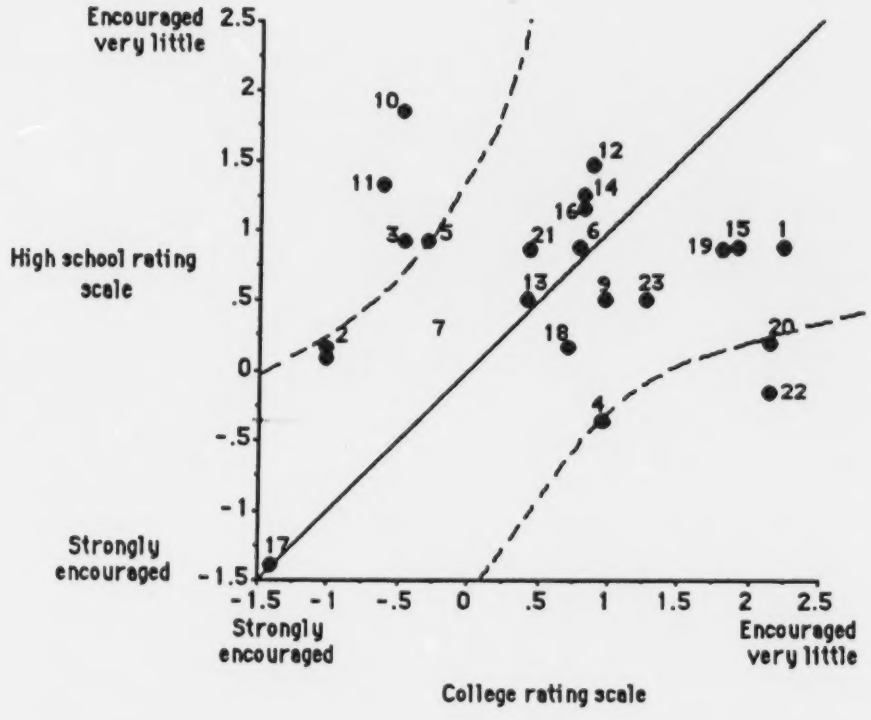
Encouraged very little
2.5
2
1.5
1
.5
0
-.5
-1
-1.5
High school rating scale
Strongly encouraged
-1.5 -1 -.5 0 .5 1 1.5 2 2.5
Strongly encouraged
Encouraged very little
College rating scale

Fig.5

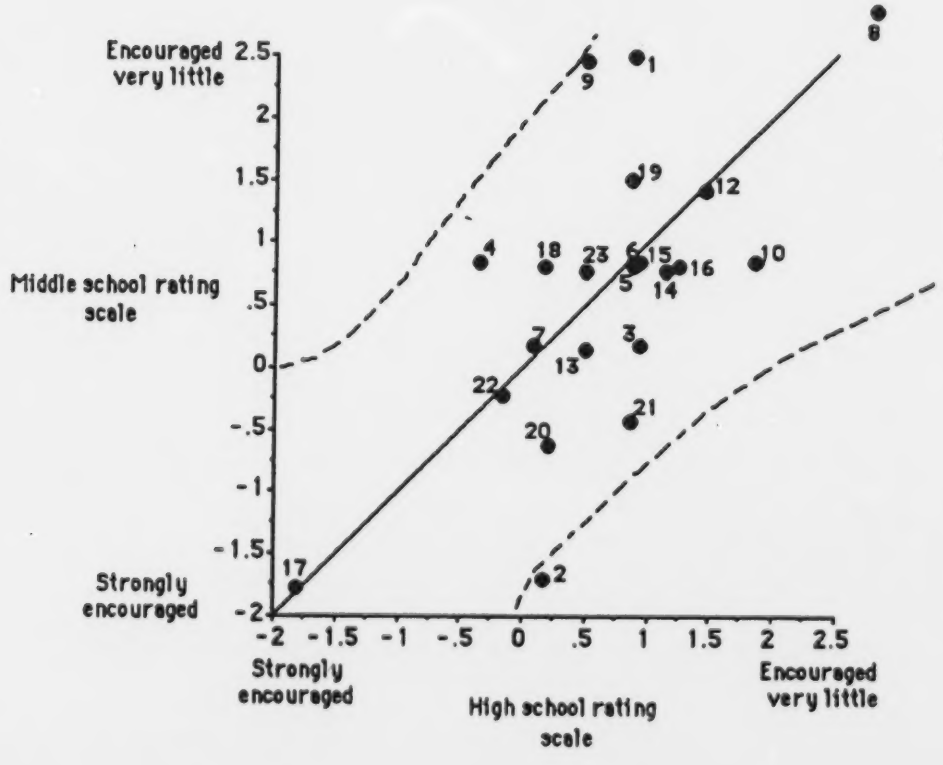
Encouraged very little
2.5
2
1.5
1
.5
0
-.5
-1
-1.5
-2
Middle school rating scale
Strongly encouraged
-2 -1.5 -1 -.5 0 .5 1 1.5 2 2.5
Strongly encouraged
Encouraged very little
High school rating scale

Fig. 6